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ABSTRACT

A study tested two alternative theories about the role of color in visual learning: first, that color provides an additional dimension of realism which results in the learner attaining a more complete image of the object or event and second, that color functions only as a coding device which facilitates the storage and retrieval of the image. Two hundred and twenty four students at Pennsylvania State University were randomly assigned to treatment groups which received the same verbal instruction but different visual supplements--black-and-white drawings, realistic color drawings, non-realistic color drawings produced by means of photographic reversal, and no illustrations. Achievement tests administered to the students immediately after the instruction showed that in those cases where instruction with accompanying visual materials was superior to instruction without visuals, realistic color drawings were most effective in facilitating achievement. No significant differences were found on delayed achievement tests administered six weeks after the instruction. (KB)

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AN INVESTIGATION OF THE EFFECTIVENESS OF REALISTIC AND NON-REALISTIC COLOR IN VISUALIZED INSTRUCTION

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STATEMENT OF THE PROBLEM

The value of visual instructional materials in facilitating classroom instruction has been recognized for some time. Research has clearly established the need for carefully prepared and organized materials to effectively augment oral instruction. Research has been less conclusive, however, in identifying those design characteristics which contributed to improved learner achievement from visual materials as well as in examining the effect on the learning process of variations within each of those design factors.

The need for such research has become increasingly apparent in recent years. Numerous public agencies and private corporations now market great quantities of visual instructional materials and devices for the production of such materials. Teachers, instructional developers and graphic designers, however, have not been provided with a set of research-based guidelines for the use and manipulation of design factors such as color, complexity, contrast and realism in the design, selection and utilization of visuals for instructional purposes. The result of this inequity has, in many cases, led to the production of visuals which interfere with rather than aid instruction.

During the past fifty years, numerous studies have been conducted concerning the relative effectiveness

of visual materials in facilitating student achievement. A serious limitation of these studies is that the visual materials were usually treated as entire units rather than as combinations of many distinct types of cues or stimulus elements. No attempts were made to systematically identify and examine those elements within a visual display which contributed to the improved learning. Rather, the practice of comparing instructional materials as entire units confounded any attempt to isolate and quantitatively define those characteristics which may have aided learning and those which impeded learning.

The use of color in instructional materials is one such element requiring further investigation. Color has long been considered a significant factor in the design of visuals for instructional applications. Its use, however, has usually been determined by two considerations totally unrelated to its possible effectiveness as a facilitator of learning. These factors, the aesthetic appeal of color over black and white illustrations and the considerably higher production cost of color visuals have worked, although at opposite ends, to determine the instructional use of this variable.

One reason for this misjudgment of priorities has been the fact that the great majority of the research regarding color has been inconclusive. In a survey of a number of studies relating to the color variable,

Otto and Askov (1968) concluded that "the cue value of color in learning is still essentially unclear."

Even more limited research has focused on variations within the color mode as a means whereby its effect as a cueing device may be more precisely stated.

The purpose of this study was to compare the relative instructional effectiveness of two forms of color cueing in visual instructional materials. Both immediate acquisition as well as delayed retention effects were examined.

BACKGROUND

Two theoretical orientations bear a close relationship to the role of color in visual learning and its associated research. These orientations both deal with the question of realism or complexity in learning from illustrations.

The first, a group of theories collectively referred to as "realism theories" by Dwyer (1967) include the iconicity theory of Morris (1946), Dale's (1946) cone of experience and the surrogate fidelity theory of Gibson (1954).. All of these theories are predicated on the assumption that the more realistic an instructional device, the more effectively it will facilitate learning. This assumption is based on the notion that the more realistic materials will present more visual cues to the learner and thus, give him more information with which to work. Justification for this assumption is provided by the basic theory of stimulus generalization and the concept of cue summation.

A conflicting orientation, however, has also drawn wide support. This group of theorists and researchers has suggested that the "realism theories" do not accurately describe how visual instructional materials function in learning, and in fact, may be in direct contradiction to the true situation.

Broadbent (1958, 1965) has described the human information processing system as a single-channel, limited capacity system which he refers to as the P-system. This system functions much like a filter in that, in times of high information reception, not all information perceived is immediately processed and stored. Rather, the P-system filters out all information beyond its capacity and holds this "overflow" for later processing. The overflow may possibly block other incoming, relevant information. Jacobson (1950, 1951) further supported this contention and indicated that only a small percentage of all information perceived is effectively stored and utilized by the nervous system.

Working from the theory of Broadbent, Travers (1964) focused specifically on the question of realism in instructional materials. He suggested that, to deal with a complex environment, the nervous system must simplify inputs and perceptions. To achieve this end, Travers described a process known as "compression." In describing this phenomenon, he indicated that to maximize the instructional effectiveness of visuals, it may be necessary to discard some elements of a

visual which contain little information. This position is supported by empirical research conducted by Cherry (1953), Attneave (1954), Spaulding (1956), Gorman (1972) and Dwyer (1972). The studies reported by Dwyer represent the single, most comprehensive group of studies in this area. He found strong evidence to indicate that the most realistic visuals are not necessarily the most effective in promoting student learning. The relevance of visual realism to the use of color is readily apparent. Color in a great many visual illustrations can represent a significant contribution to the realism depicted in those visuals.

Research related specifically to the use of color has, similarly, been inconclusive. In a number of studies investigating the use of color in instructional visuals (VanderMeer, 1952; Kanner and Rosenstein, 1960, 1961; and Katzman and Nyenhuis, 1972) it was generally concluded that color has no significant effect on learner achievement.

More recent studies, however, have reported conflicting data. Color was found to be a significant design factor in research conducted by Bourne and Restle (1959), Saltz (1963), Underwood (1963), Dwyer (1972) and Lamberski (1972).

SPECIFIC ORIENTATION OF THE PRESENT STUDY

When the results of those studies related to complexity or color are taken into consideration, it seems apparent that, as Otto and Askov (1968) indicated,

the "cue value of color" is not clear. Limited research has focused on the effect of variations within the color mode of presentation as a means whereby the cue value of color may be more adequately investigated and described. The basic question, therefore, to which this study addressed itself was: In what manner does color function as an instructional variable?

Two alternative explanations appear possible. First, that color provides an additional dimension of realism which results in the learner attaining a more complete or realistic image of the event or object; or, second, color functions only as a coding or cueing device which facilitates storage and retrieval of the image or information. If the former alternative is true, then a realistic color visual should facilitate retention of material to a greater degree than a non-realistically colored visual. If the latter alternative is true, then all types of color visuals should function equally well in facilitating retention of material. Similarly, all forms of color could also be expected to be superior to black and white visuals in promoting the learning of material related to specific educational objectives.

The purpose of this study was to compare the relative effectiveness of two forms of color cueing, used in visual materials to facilitate the learning and retention of meaningful material within four instructional objectives. Specifically, the two forms

of cueing devices can be identified as realistic and non-realistic color. Realistic color being representative of the use of realistic colors which present the learner with a relatively realistic version of the object or scene described, and non-realistic color being representative of the artificial use of color solely as an additional visual cue which has no relation to the actual color of the object or scene.

A common problem in the literature deals with the task of designing equivalent materials to test the color hypothesis. The very nature of the color visual militates against attainment of equivalence. Specifically, the use of color in a visual adds a much greater number of visual cues to the display, resulting in a greater amount of available information. According to what the research has indicated, the greater quantity of information would appear to require more time to be perceived, processed and stored. This would perhaps explain why color effects appeared primarily in a number of self-paced studies reported by Dwyer.

The present study attempted to eliminate the lack of equivalence by equating the actual number of visual cues presented while simultaneously altering the type of color cueing device. By photographically reversing the original color image of the visual, the exact number of color cues may be held constant, yet the resulting color still functions as a cueing or coding device.

It would appear, that since the task of assigning values to all color cues presented in a given visual could be virtually impossible, this means of controlling the number of cues would offer a fruitful means of investigating the effects of color as a cueing device. By means of this technique, both the realism orientation as well as the color coding hypothesis may be more precisely studied and explained.

INSTRUCTIONAL MATERIALS

The materials employed in this study consisted of six instructional programs on the human heart, its parts and its functions during the diastolic and systolic phases presented by means of slides and audio tape. This instructional unit was developed by Dwyer (1967) and has undergone extensive validation with over 5000 students. Each of these programs contained a series of visuals intended to complement the same oral script. Two sets of visuals were prepared in realistic color and two sets were produced in non-realistic color by means of photographic reversal. The remaining two sets were prepared in black and white and non-illustrated formats, respectively.

Photographic reversal was used as a means of producing visual materials in which the total number of visual cues were held constant while the degree of realism (color - realistic or non-realistic) could be manipulated.

In this case, all colors were systematically reversed to their opposite or complementary color, i.e. reds and browns were reversed to blues, grays and greens; yellows to violet and whites to black.

Measurement of achievement was accomplished by the use of five tests developed by Dwyer for the evaluation of student achievement in the areas of drawing, identification, terminology comprehension and total understanding.

EXPERIMENTAL PROCEDURE

The data for this study were obtained from 224 college students enrolled in the Instructional Media 411 course at the Pennsylvania State University.

During orientation sessions to the course, all S's were requested to complete two pretest instruments, the Otis Mental Ability Test (Form FM) and a general pretest in the content area.

Subjects were randomly assigned to one of six treatment groups. These treatment groups received the same oral presentation; however, each of the six groups received their own respective type of visual illustration. These groups represented (1) non-illustrated; (2) black and white shaded drawings; (3 & 5) realistic color drawings; (4 & 6) non-realistic color drawings.

Immediately after participating in their respective instructional treatment, S's were administered the battery of achievement tests. Six weeks later students met again for the delayed posttest battery.

STATISTICAL ANALYSIS

Analysis of covariance was selected as a means of analyzing the data. Lindquist (1953) has indicated that th precision of an experiment may be increased considerably

by use of analysis of covariance when the correlation between the adjusting variables (covariates) and the criterion variables is high. A Pearson Product moment correlation was conducted between each of the immediate and delayed achievement posttests and the two pretest measures. In all instances, the Pearson r correlation coefficient was significantly different from zero at the .01 level. Accordingly, these two pretest measures were selected for use as adjusting variables in the analysis of covariance.

In those cases were a significant F-ratio at the .05 level was indicated by the analysis of covariance, further analyses were conducted between all possible pairs of adjusted means via the Tukey Wholly Significant Difference Test (Tukey's WSD Test).

COMPARISONS OF THE SIX TREATMENT GROUPS IN THE IMMEDIATE POSTTESTS

The analysis of the immediate test scores via analysis of covariance produced the following F-ratios: Drawings - 2.94, Identification - 3.01, Terminology - 3.02, Comprehension - 0.35 and Total Test - 3.15. Four of these F-ratios (Drawing Test, Identification Test, Terminology Test and Total Test) exceeded the critical F-value of 2.26 at the $p < .05$ level.

Multiple comparisons between adjusted means were made in each instance where a significant F-ratio was obtained. In every case, Group V (realistic color) was found to be significantly superior to Group I (non-illustrated group) at the $p < .05$ level. (See Tables 1, 2, 3, 4 & 5.)

Table 1. Analysis of Covariance on the Immediate Drawing Test Scores for the Six Treatment Groups.

Variance	D.F.	Adjusted Analysis Sum of Squares	Mean Square	F	p-value
Among Groups	5	188.92	37.78	2.94*	< .05
Within Groups	216	2773.70	12.84		
Total	221	2962.62			

*Significant at the p < .05 level.

Table 2. Analysis of Covariance on the Immediate Identification Tert Scores for the Six Treatment Groups.

Variance	D.F.	Adjusted Analysis Sum of Squares	Mean Square	F	p-value
Among Groups	5	198.52	39.71	3.01*	< .05
Within Groups	216	2852.40	13.21		
Total	221	3050.92			

*Significant at the p < .05 level.

Table 3. Analysis of Covariance on the Immediate Terminology Test Scores for the Six Treatment Groups.

Variance	D.F.	Adjusted Analysis Sum of Squares	Mean Square	F	p-value
Among Groups	5	188.78	37.76	3.02*	< .05
Within Groups	216	2703.20	12.52		
Total	221	2891.98			

*Significant at the p < .05 level.

Table 4. Analysis of Covariance on the Immediate Comprehension Test Scores for the Six Treatment Groups.

Variance	D.F.	Adjusted Analysis Sum of Squares	Mean Square	F	p-value
Among Groups	5	19.18	3.84	0.35	n.s.
Within Groups	216	2361.10	10.93		
Total	221	2380.28			

Table 5. Analysis of Covariance on the Immediate Total Test Scores for the Six Treatment Groups.

Variance	D.F.	Adjusted Analysis Sum of Squares	Mean Square	F	p-value
Among Groups		2020.40	404.08	3.15*	< .05
Within Groups	216	27742.00	128.43		
Total	221	29762.40			

* Significant at the $p < .05$ level.

COMPARISON OF THE SIX TREATMENT GROUPS ON THE DELAYED POSTTEST MEASURES

Analysis of the data obtained from the six treatment groups on the five delayed (6 weeks) posttests produced the following F-ratios: Drawing Test - 0.91, Identificati Test - 0.82, Terminology Test - 0.26, Comprehension Test - 0.92 and Total Test - 1.07. All of these values were non-significant at the $p < .05$ level of significance. (See Tables 6, 7, 8, 9 & 10.)

Table 6. Analysis of Covariance on the Delayed Drawing Test Scores for the Six Treatment Groups.

Variance		Adjusted Analysis			
	D.F.	Sum of Squares	Mean Square	F	p-value
Among Groups	5	69.41	13.88	0.91	n.s.
Within Groups	216	3280.70	15.19		
Total	221	20545.00			

Table 7. Analysis of Covariance on the Delayed Identification Test Scores for the Six Treatment Groups.

Variance		Adjusted Analysis			
	D.F.	Sum of Squares	Mean Square	F	p-value
Among Groups	5	55.88	11.18	0.82	n.s.
Within Groups	216	2950.10	13.66		
Total	221	29447.00			

Table 8. Analysis of Covariance on the Delayed Terminology Test Scores for the Six Treatment Groups.

Variance	D.F.	Adjusted Analysis Sum of Squares	Mean Square	F	p-value
Among Groups	5	12.51	2.50	0.26	n.s.
Within Groups	216	2096.40	9.71		
Total	221	19783.00			

Table 9. Analysis of Covariance on the Delayed Comprehension Test Scores for the Six Treatment Groups.

Variance	D.F.	Adjusted Analysis Sum of Squares	Mean Square	F	p-value
Among Groups	5	47.57	9.51	0.92	n.s.
Within Groups	216	2245.20	10.39		
Total	221	20248.00			

Table 10. Analysis of Covariance on the Delayed Total Test Scores for the Six Treatment Groups.

Variance	D.F.	Adjusted Analysis Sum of Squares	Mean Square	F	p-value
Among Groups	5	654.86	130.97	1.07	n.s.
Within Groups	216	26526.00	122.81		
Total	221	339660.00			

A summary of those presentations most effective in facilitating learner achievement on each test is presented in Table 11.

Table 11. Treatments Most Effective in Facilitating Achievement on Each Achievement Test as Compared with the Non-illustrated Treatment.

Achievement Test	Immediate Posttest	Delayed Posttest
Drawing Test	Realistic Color Presentation	-
Identification Test	Realistic Color Presentation	-
Terminology Test	Realistic Color Presentation	-
Comprehension Test	-	-
Total Test	Realistic Color Presentation	-

CONCLUSIONS AND DISCUSSION

A number of conclusions can be drawn from the analyses obtained in this study.

1. Different visual materials incorporating different degrees of visual complexity or different types of cueing devices, i.e., realistic and non-realistic color, are not equally effective in facilitating student achievement relative to different instructiona objectives.
2. The data suggest that in those cases where visual materials were significantly more effective than instruction without visuals, realistic color cued

visuals were most effective in facilitating student achievement.

3. The data further indicated, in those cases where color visual instructional materials were superior to verbal materials, that realistic color materials were more effective than non-realistic color materials. Since the overall number of visual cues presented in any corresponding pair of color visuals (realistic and non-realistic) were the same, it must be concluded that the increased effectiveness of the realistic color materials was due to the factor of realism.

This conclusion does not, however, support the principle of cue summation. Cue summation suggests that merely increasing the number of available cues would improve achievement. In this study, the relative number of visual cues was held constant across each color treatment, yet differences in achievement in favor of the realistic color group was observed.

It can generally be concluded therefore that the concept of realism is, to a limited degree, an important factor for consideration in the design of visual instructional materials. It can further be concluded that realism in a visual display is a factor which should be considered in addition to the total number of visual cues presented. In terms of the design of instructional materials, this would mean that teachers and designers should avoid

the use of non-realistic colors or shadings in visuals unless they serve a specific purpose, such as to make parts or objects more distinct from one another or from a background.

4. Evidence suggests that while visual materials used to complement instruction facilitate immediate retention of information, these effects disappear after six weeks.

RECOMMENDATIONS FOR FURTHER RESEARCH

Based on the findings of this study, several areas of replicative or exploratory research become apparent.

1. The study should be replicated in other learning tasks, especially with varying levels of complexity.
2. A similar study should be conducted using the same materials presented in an internally or self-paced format rather than externally paced. In this way, the time with which students interact with the visual materials could be examined as a significant variable contributing to the effectiveness of color as a cueing device.
3. Further research is necessary to determine if the apparent superiority of realistic color is due purely to its degree of realism or rather to a combination of realism and additional color cues.
4. Additional research is suggested using other forms of non-realistic or unfamiliar color as cueing devices.

5. Previous studies of realism or complexity in instructional visuals as well as the present study have maintained the same relative degree of complexity across all visuals in the instructional presentation by using the same form of illustration throughout. As an example, the present study used detailed, shaded drawings throughout each presentation. Other studies have used all photographic or all line diagram visuals. No combination of different illustration techniques has been investigated

As a result of the present study, it is hypothesized that learning might be facilitated to a greater degree by beginning an instructional sequence with simplified visuals and then proceeding to make the visuals more complex and more lifelike or realistic as the learner becomes more familiar with the basic information or better oriented to the visual arrays.

Further research should, therefore, focus on the effects of varying the mode of illustration within a given instructional presentation. In this way, visual complexity could be manipulated in relation to the sequencing of visuals. Studies of this nature would further investigate the usefulness of the "realism theories" as descriptors of how individuals learn from visual illustrations.

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